ARM
Automation, Inc.

Electro-Hydrostatic Transmission and Control Technology for Modular D&D Manipulators

Technology Need:

Many D&D activities require the use of remotely operated tools for the inspection, characterization, and dismantlement of facilities and equipment. These activities require an array of robotic mechanisms. Remote D&D operations demand manipulators that can accommodate heavy payloads and generate high forces. The current solution to this challenging application, a hydraulic manipulator, has several drawbacks. The hydraulic power source consists of a large motor, pump, reservoir, and hoses that transport the pressurized supply and return fluid. The power source is heavy and noisy. The connecting hoses are difficult to handle and prone to leakage, which in a contaminated environment causes a serious mixed waste issue. A failure can result in a leak of gallons of fluid in an instant. Installation of the power source outside of the contaminated area creates a risk of transporting contamination across the boundary. Despite these drawbacks, hydraulic systems are used because they offer the highest volumetric force/torque density of any mature actuation technology at a reasonable cost. In addition, DOE has many unique automation requirements. Developing a custom system from scratch is prohibitively expensive and time consuming. The solution to this problem is a modular architecture and system of pre-engineered actuators and links that can be quickly combined to create a manipulator suited to a task.

Technology Description:

ARM Automation, Inc. (ARM) developed an extremely compact, embedded electronic controller and actuator that enables increased modularity. To date, ARM has developed two sizes of electro-mechanical actuators (EMAs). These are suitable for tasks with moderately heavy payloads (10kg). Many D&D tasks, however, require higher payloads (over 50kg) and longer reaches. To meet these goals, actuators with increased torque capacity are needed. Under this development effort, the existing architecture is being extended with closed-loop electro-hydrostatic technology that combines the best of hydraulic systems (high torque) with the best of electro-mechanical systems (modularity, controllability, cleanliness). Traditional hydraulic systems power the actuator from a manifold and control actuator position with a spool valve. While this approach permits a single pump to power multiple actuators, it is energy intensive and suffers from the drawbacks described above. In a hydrostatic system, each hydraulic motor is matched to its own pump integrated into the same housing. Common examples are floor jacks and hydrostatic transmissions. This technology embodies the novel approach of position control of a hydrostatic actuator by servo-controlling the electric motor driving the pump rather than using a spool valve. A complete electro-hydrostatic actuator (EHA) compatible with ARM's existing architecture is being developed. There will be no external hydraulic lines or connections and the volume of fluid contained in the actuator will be minimal. It is estimated that this design will offer 3 - 5 times the torque density of ARM's current designs (which already are several

times better than prior electro-mechanical actuators).

Benefits:

▸Safe handling (sharp edges, points and pinch points have been minimized).

▸Lightweight (1/4th to 1/6th weight of conventional electric robot for equal payload & reach).

▸Sealed against particles, gases, and liquids.

▸Easily field serviceable (modules can be carried by hand and changed out in seconds).

▸Durable in harsh EM environments (all modules are sealed, all metal exterior, no external wiring, all digital communications).

▸Open controls for integration with other systems.

Status and Accomplishments:

The basic technology of an EHA control architecture and transmission is being developed to determine the feasibility of this approach. Technical challenges are foreseen in controllability and packaging.

For controllability, a control approach and algorithm were simulated using a mathematical model of the physical plant and control algorithm. An EHA test bed (see figure) has been fabricated to verify the results of the simulation. A controllable load combined with torque, pressure, position and current transducers, and data-acquisition equipment will be used to evaluate actuator performance across its operating range.

The packaging challenge lies in two areas. Most off-the-shelf hydrostatic transmission components are designed for use in applications where indestructibility rather than weight is the driving criterion. It is expected that significant weight savings will be realized by eliminating redundant housings, bearings, couplings, and fittings. The second part of the packaging challenge lies in the physical arrangement of a hydrostatic transmission with an adequate reduction ratio in a high-pressure housing. This will be addressed through evaluation and selection of the most appropriate hydrostatic technology (for example, gerotor, helical screw, vane, piston) and conceptual design of a packaging arrangement.

On DOE approval, ARM will design and fabricate a fully integrated EHA compatible with ARM's existing EMA architecture. The technical challenge is anticipated to be the integration of the hydrostatic components in a compact, lightweight package. The conceptual hydrostatic design will be refined by working closely with a hydrostatic component vendor.

On DOE approval, a complete manipulator, composed of EHA modules, will be tested at a DOE site to determine functionality, capability, and compatibility with the processing of nuclear materials.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 3165
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit the ARM Automation, Inc. website at http://armautomation.com/